Evolution and Earths Entropy

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I greatly enjoyed the interesting insights in Styer's[1] and Bunn's[2] articles on entropy and evolution and would like to add a couple of points.

Styer showed the total entropy throughput rate for the Earth to be about 4×10^{14} J/K s and estimated a maximum rate of decrease in entropy from evolution of the order of 3×10^{2} J/K s. Bunn did a more robust analysis of evolutionary entropy change and determines it to be far less than 10^{21} J/K over the history of the Earth. For a 4.5×10^{9} year old Earth, this is about 10^{4} J/K s.

Styer noted the evolutionary entropy decrease is many orders of magnitude below the Earth entropy throughput, and this holds even for Bunn's estimate. Both authors took, as their starting point, the principle that $\Delta S \geq 0$ for an isolated system and identified that system to be the Earth plus those objects with which the Earth exchanges energy. They then showed that the total entropy of this system increases, even when the estimates for evolutionary decreases are included. However, neither discussed the Earth itself as a system (not thermally isolated) and the mechanism for the overall entropy decrease within that system, which underlies the growth of all life as we know it.

The decrease in entropy for the Earth system can be attributed to the incoming heat from the sun occurring at higher temperature on the planet's surface during the day, whereas the same amount of heat (approximately, on average) leaving the planet during the subsequent night is at a lower temperature. Hence, $|\Delta Q/T_{in}| < |\Delta Q/T_{out}|$ and Earth's entropy decreases. A quick estimate, assuming 5 $^\circ$C average variation between night and day, shows this to be on the order of 2% of the Earth entropy throughput, i.e., greater than 10^{12} J/K s. Nonequilibrium energy exchanges solely on and within the Earth also produce entropy, effectively reducing the net decrease to something near the relatively miniscule levels Styer and Bunn suggested.[3][4]

I do note that the total entropy decrease should not correlate solely with the existence of more complex organisms than at earlier times, which Styer discussed, but also to a greater total number of organisms. The human race, for example, has over 5×10^{9} more individuals now than it had a couple of centuries ago, and all of these are far more organized than the base elements and compounds were before they formed those individuals' bodies.

Further, it seems that living creatures, particularly human ones, organize things around themselves into lower entropy configurations that last beyond the lives of those creatures (whose deaths lead to local increases in entropy). Cathedrals erected from stone, and societies emerging from clans, are two examples, though in the latter case, I may, as Styer warned against, be intermingling the metaphor with the definition.

None of this contradicts anything in the articles. The entropy decreases involved in evolution, by any estimate, remain many orders of magnitude less than the total entropy gain of the universe, the total Earth entropy throughput, and importantly, the net planetary entropy decrease from day/night temperature differences. This trumps the creationist argument, addressed by both authors, that claims science is somehow internally inconsistent with regard to evolution.

References

[1] D. F. Styer, "Entropy and evolution," Am. J. Phys. **76**(11), 1031-1033 (2008).

[2] E. F. Bunn, "Evolution and the second law of thermodynamics," Am. J. Phys. **77**(10) (2009).

[3] For a constant volume, closed system in thermal contact with its surroundings, $\Delta S = \sum_i (\Delta Q/T)_i + \Delta S_{internal}$, where the last term is due to nonequilibrium processes and is always positive. For the Earth, the summation terms are, effectively, $|\Delta Q|/T_{in} - |\Delta Q|/T_{out} < 0$, which can, and do, lead to $\Delta S < 0$ within the system.

[4] L. C. Epstein, *Thinking Physics*, 2^{nd} ed. (Insight Press, San Francisco, 1999), p. 250. The author makes the following point. "If the sun's disc were smeared out (evenly) over the whole sky, the Earth's atmosphere would .. not circulate at all." Uniformly distributed radiation in and out would mean a static, lifeless planet.